

circ. 1.5 mm. longis; glandulae 2, ventralis ovoideo-conica vel saepe bipartita, bractea subtriplo brevior, dorsalis minima interdum plusminusve 3-partita; amenta feminea sub anthesi nondum visa, adultiora circ. 3.5-4: 2 cm. magna (pedunculo ad 1-2 cm. longo 3-4-foliolato excluso), basi plusminusve laxiflora, fructifera ad 5:1.6 cm. magna; bracteae ut in masculis, saepe omnino breviter pilosae; ovaria anguste ovoideo-oblonga, dense breviter argenteo-sericeo-tomentosa; styli distincti, 0.8-1.3 mm. longi, apice saepissime bifidi, stigmatibus oblongis divaricatis bifidis stylo paullo ad duplo brevioribus; pedicelli initio glandulam duplo dein ad triplo superantes, in fructu circ. 2 mm. longi; glandula 1, late ovoideo-rectangularis, saepissime bipartita. Fructus maturi e basi ovoideo-rhombica rostrati, 8-10 mm. pedicello excluso longi, ut ovaria tomentosi.

SPECIMENS EXAMINED: ALBERTA. Edge of Bow River, near Cave and Basin, about 1500 m., July 10, 1899, *W. C. McCalla* (No. 2252^a, partim, f.; N.); vicinity of Banff, on water's edge along road to Sun Dance Canyon, about 1500 m., July 10, 1890, same coll. (No. 2252^a, partim; Cor.; "about 1 m. high"); low ground along road to Devil's Head Lake, about 1500 m., June 19, August 11, 1899, same coll. (No. 2252, type, m., st.; Cor. "1.5 m. high"); Banff, August 13, 1908, *Olson* (f.; G.); Morley, foothills of Rocky Mts., damp places, June 17, 1885, *J. Macoun* (No. 24506; O.; olim No. 17, C.); Banff, Cave Avenue, July 4, 1891, same coll. (No. 24517, fr.; O.; olim nos. 28 and 33 in C.); marshy flat near the Bow River, July 15, 1891, same coll. (No. 28, fr., C.; "bush 1.2 m. high"); Spray River, June 30, 1891, same coll. (No. 33, fr.; C.; "low spreading bush on the borders of the same marsh").

BRITISH COLUMBIA. Yale District, Armstrong in the Okanagan Valley, 1912, *E. Wilson* (No. 2, f., m., fr.; Cor.; in O. sub No. 87817); Kootenay District, Cranbrook, June 22, 1914, *J. K. Henry* (fr.; Cal.; "clumps 1.2 to 1.8 m. high").

SASKATCHEWAN. Prince Albert, Camp, thickets by railway, July 6, 1876, *J. Macoun* (No. 13675, st.; Cor., O.); west of Eagle Creek, Bare Hill, in a bog, July 31, 1906, *J. Macoun & W. Herriot* (No. 70260, st., O., G.).

MANITOBA. In thickets east of Brandon, June 6, 1896, *J. Macoun* (No. 13666, fr. im.; C., Cor., O.).

ONTARIO. Thunder Bay District, Lake Superior, north shore, by C.P.R.R. in SW. between Port Arthur and Fort Williams, July 23, 1883, *W. R. Dudley* (f.; C.).

VIENNA, May, 1920.

THE LIGNEOUS FLORA OF THE STAKED PLAINS OF TEXAS

ERNEST J. PALMER

THE traveler who has passed over the high, wind-swept, grassy plains of the Texas Panhandle and viewed the country only from the speeding train might perhaps imagine that an article on the trees and shrubs of the region could be as brief and trite as the celebrated treatise on the Snakes of Ireland; but a closer inspection will reveal the fact that even if Nature has essayed a sinister imitation of St. Patrick's rôle upon the ligneous flora here it has been carried out but indifferently, and that although largely confined to certain limited areas woody plants are by no means rare and the total number of species is not inconsiderable. Moreover, instead of showing any tendency

to abandon the country, both in area occupied and in number of forms, there appears to be a steady if slow increase in progress at the present time.

The southern portion of the Great Plains, occupying western Texas, rises gradually or by a series of step-like plateaus from the lower Rio Grande valley, with a maximum elevation of only a few hundred feet above sea-level, to the high plains of the Panhandle, parts of which exceed four thousand feet in altitude. The first of these, if we exclude the Rio Grande Plain, which properly belongs to the Gulf Coastal Plain, is the Edwards Plateau, set off from the lowlands by the bold Balconies Escarpment; the second is the Staked Plains, lying to the northwest of the rocky plateau and rising gradually from it. The boundary between these two regions must, therefore, be somewhat arbitrarily drawn, but in general it may be regarded as following the line of contact between the limestones of the Comanchean Series and the overlying Tertiary or Quaternary deposits, principally of gravels, sands and other unconsolidated materials, that constitute the surface formations of most of the Staked Plains area. This line runs in a southwesterly direction from near the town of Big Spring, in Howard County, to the valley of the Pecos River, in Crane County, which it follows thence at an angle of about forty-five degrees northwestward into New Mexico. On the eastern side the plateau rises abruptly from the lower bordering plain by a high escarpment or line of cliffs, the crown of which is formed by a hard, thick stratum, usually of the recent, non-marine limestone or "caliche." The more resistant nature of this upper layer is responsible for the bold character of the cliffs, and it is locally known as the "cap-rock" or "rim-rock." The escarpment is also well defined on the north, where it forms a wall of the deep valley of the Canadian River, which separates the Staked Plains from the next successive, higher stage, the Panhandle High Plains. On the west it is bounded by the valley of the upper Pecos River, in New Mexico. The margins of the plateau are in places deeply incised by the canyons of streams which have their sources in the highlands. The most important of these are on the eastern side the various branches of the Colorado, Brazos and Red Rivers, and on the west those of the Pecos. It is in these canyons and along the ravines and broken ground bordering them that most of the ligneous plants are found, and many of them are confined to such protected situations or to the marginal escarpment of the plateau.

Viewed as a whole the Staked Plains is a high, mesa-like tableland, with a remarkably level surface over its interior, and nearly destitute of running streams. The rainfall is sparse, the annual average ranging from fifteen to twenty-five inches, and its elevation and exposed position in the vast plains stretching unbrokenly from the Arctic Ocean to the Gulf of Mexico, gives it a somewhat rigorous climate, marked by great extremes of temperature, both seasonable and diurnal. Dry winds of high velocity prevail during the greater part of the year, and under their influence the potential evaporation is much greater than the total average rainfall. In addition to the normal severity and wide variations of the climate its effect upon life

conditions is augmented by the frequent tornados, blizzards and long periods of drouth to which the region is subject.

The broad plains forming the summit of the plateau present for many miles an almost featureless surface. The streams, so-called, are merely wide, shallow stretches of gravel and sand, devoid of running water or even pools except for short periods after the infrequent rains. Their courses are generally comparatively straight, with very slight fall and practically without banks.

Ascending from the lower level over the steep grades or precipitous passes of the escarpment the appropriate significance of the colloquialism, "on the plains," is apparent. Far as the eye can see extend the unbroken, grassy stretches of level surface, conveying an impression of boundless space comparable only to the great sandy deserts or to the ocean. The only natural features that vary the landscape are here and there broad, shallow depressions or sinks, defined by the deeper green of their more luxurious herbage, and perhaps the far-flung glistening ribbon of one of the waterless streams in the distance. In the refracted light of the dazzling summer sun may be seen the inverted images of cattle, buildings, fences and trees along the horizon on either hand, mirrored in the phantom lakes of the mirage. Scarcely more marked or impressive in the magnificent distances than the few and slight inequalities of nature are the tangible evidences of civilization: the ranch houses and stock sheds with the ever-present windmills, many miles apart; fences and roads no less remote, and the grazing herds of cattle that have come with the plainsmen and cowboys as successors to the once numberless buffalo and the nomadic Indians, that not many years ago held undisputed sway over these broad prairies. The traveler is sometimes startled into a realization of how very recent is the period of this great cultural transition by coming upon the whitened skulls of the bison, still occasionally to be seen about salt licks or along the streams, or by turning up the flint or obsidian arrow-heads of the primitive hunters.

Underground solution of salt, magnesia and other mineral matter has resulted in the formation of the numerous shallow depressions that are in many places so conspicuous a feature of the plains topography. These are sometimes many acres in extent but seldom more than a metre or so below the general level at their greatest depth, and as the sides slope gently towards the centre they appear to be even shallower. Following the heavier rains many of these sinks become shallow lakes, but this condition generally continues for only a short time. Practically all of the water disappears in a few days or weeks at most by evaporation, very little of it sinking to any great depth into the ground. After the water is gone a rank growth of coarse grasses and rushes springs up, and as the herbage on the level plain becomes dry and brown the contrast in color is quite striking.

The flora of the open plains is essentially grassy; species of *Bouteloua*, *Andropogon* and *Festuca* being very abundant. Many annual and perennial species of flowering plants are found but most of them are conspicuous only for a short time after the rainy season. Low mat-like forms are common,

with wide-spreading branches close to the ground the better to resist the constant buffeting of the dry winds. Owing to the generally light rainfall and rapid evaporation the subsoil contains little moisture and this condition, together with the great depth of ground water, offers little incentive to deep-rooted plants, those having wide-spreading, shallow root systems being the prevailing types. Ligneous plants are almost entirely absent. Occasional stunted bushes of Mesquite and the low Cat's Claw (*Mimosa borealis*) or the shrubby Senecio may sometimes be found along the slight depressions of stream beds and ravines.

The Mesquite (*Prosopis glandulosa*), which is the most frequent woody species, is here strictly shrubby, seldom attaining a height of more than one or two metres. This plant, which makes a small tree under favorable conditions, with a maximum height of twelve or fifteen metres and a trunk diameter of four or five decimetres, is everywhere in this region the most hardy pioneer of advancing forestation. It has extended its range from its original home, probably south of the Rio Grande, until it now occupies all of the lowlands of the Rio Grande plain, the lower open canyons of the Edwards Plateau and those of the Staked Plains, encircling these tablelands and extending westward through the canyons and river valleys of New Mexico and Arizona and northward into western Oklahoma. Scattered specimens are found as far north as southwestern Kansas and eastward in Texas to the boundary of Louisiana. As the most abundant and widely distributed ligneous plant over hundreds of square miles it is familiar to all travelers in the Southwest, and numerous accounts of it appear in the literature, both scientific and general, dealing with that part of the country. Over a large part of western Texas it is the only species that attains the size of a tree and it is therefore of the greatest value to the ranchers and settlers in the construction of fences as well as for fuel and other purposes. The wood is of rapid growth and rather durable; the beans and foliage are eagerly eaten by stock and furnish a valuable addition to the forage at times when grass and other herbage is dried up. Although the thin foliage affords but indifferent protection from the scorching summer sun, as the only refuge, often, in a dry, hot land its shade is most grateful both to man and beast. The testimony of travelers and early settlers in western Texas agrees that Mesquite was absent or rare not many decades ago in much of the region where it is now so abundant. While evidence of this sort must always be received with caution there can be little doubt that it has advanced widely to the northward and eastward in recent years and that the forward movement is still going on with undiminished rapidity. One of the stories told of its introduction into Texas is as follows:

At an early day in the history of the territory when the Franciscan padres were establishing missions in the San Antonio country and zealously striving, under the banner of the cross, to bestow the blessings of the true faith upon the benighted natives, while Spanish adventurers from Mexico were seeking no less assiduously, by argument of the sword, to separate them from their more material possessions and to locate the fabulous

mines and rich cities of the interior, rumors of which had reached them from earlier explorers and from native traditions, the burrows, which were the pack animals of their caravans, were fed largely upon the beans of the Mesquite, and in this way the tree was first established in the country. My informant assured me that their route from the Rio Grande, up through the Spanish Pass northwest of San Antonio, towards San Saba and the interior, could formerly be traced by the growth of Mesquite along it, and that subsequently it had spread over the country in all directions from this nucleus. I cannot vouch for the authenticity of this account, but certainly the trail of the old Spaniards pointed out through the region is near the centre of distribution of the Mesquite in Texas and it does not seem impossible that it may have been, at least in part, introduced in this way. In recent years its dissemination over wide areas has been accomplished largely by the domestic animals that feed upon it. It is claimed that in the arid regions the seeds will germinate only after having passed through the stomachs of animals. Certain it is that the undigested seeds are often distributed and the plant established in this way.

Along the southern border of the Staked Plains there is a gradual transition from the flora, as from the topography, of the Edwards Plateau and a number of the more hardy woody species of the latter region persist for some distance into the plains. Some of the trees and shrubs find their northern limit about the buttes and ridges of Comanchean limestone that appear at intervals through the more recent residual deposits, but others reappear in the canyons or persist about the marginal rim of the elevated plains. Amongst those of the former class appear to be the Riverside Walnut, Western Red-bud, Live Oak, Mexican Buckeye and deciduous Coral Bean (*Prosopis affinis*); more persistent are the Shin Oak, the Red-fruited Juniper, Hackberry, Argireta (*Mahonia trifoliata*), Gum-elastic (*Bumelia texana*) and wild China (*Sapindus Drummondii*). In flats and depressions shrubby species from the Rio Grande Plain and the more arid regions to the southwest appear. Typical of these are the Creosote Bush (*Larrea tridentata*), the slender Cactus (*Opuntia leptocaulis*), *Rhus microphylla* and *Koeberlinea spinosa*.

The marginal escarpment of the plateau with its high, perpendicular cliffs, frequently overhanging ledges of cap-rock and deep indenting coves and ravines, affords protection to many plants that are unable to maintain themselves in more open situations; but as most of the ligneous species found here are also common to the canyons, some of which have worked far back into the interior, they will be mentioned in that connection.

The streams which traverse the upper plains, with their very slight fall and shallow channels, serve to carry off the surplus water after heavy rains. However, owing to the flatness of the country, the generally dry atmosphere and almost constant winds, the amount of water that reaches them is very small in proportion to the area, most of it remaining on the surface and disappearing in a short time through evaporation. Under these conditions there is little erosion through the action of the streams in this part of their

courses; but as they approach the marginal rim the grade becomes suddenly accelerated; cascades or rapids are formed as they plunge over the precipitous cap-rock or rush down the steep slopes of the escarpment. While the streams in this stage are intermittent and their work continues for only a short time after rainy periods they are at such times very active and the nature of the deposits they encounter is generally quite favorable for rapid excavation. After the hard stratum of cap-rock has been broken down, which is accomplished rapidly along the overhanging ledges, the soft underlying strata are easily removed. When the level of ground water is reached, which in the high plains is often several hundred feet below the surface, springs begin to issue along the canyon walls and the streams become perennial.

The small streams forming the headwaters of Red River have worked out deep channels for many miles back into the interior of the plateau. The Paloduro Canyon in Randall and Armstrong Counties, the largest of these, is one of the most remarkable erosion features of the plains and of the entire Southwest. Beginning as several narrow, shallow ravines near Canyon City it rapidly deepens and widens until in some places its floor is from 800 to 1000 feet below the level of the plains and more than ten miles in width. This enormous amount of excavation has been accomplished by a small stream in comparatively recent geological times and the work of deepening and widening it is going on with undiminished force and rapidity at present. During the summer of 1918 several days were spent by me in exploring this canyon and in studying and making collections of the plants found in it and upon the surrounding plains. As the ecological conditions and flora are quite characteristic of this interesting phase of the Staked Plains the following notes on the trees and shrubs found in this canyon may be regarded as of general application.

Approaching the canyon in its deeper sections across the plains is an interesting experience. Before you lies the seemingly endless prairie, almost as level as a billiard table; in the distance, perhaps, you see a ranch house with its outbuildings and windmills; not a ripple marks the surface of the plain and there is no apparent obstacle to prevent you continuing in a direct course to the settlement. Suddenly you come upon a shallow ravine eating its way into the plain; some low Juniper or Mountain Mahogany bushes appear along an eroded slope for a few yards and then all at once you stand upon the brink of a precipice and at your feet lies a chasm some miles in width and several hundred feet deep. On the opposite side you make out the horizontal line of the plain which continues thence as if unconscious of the interruption. Far down below, the course of a tiny stream meandering through the broad valley is marked by a fringe of trees. The canyon walls are nowhere perpendicular for their entire height, as in some of the western canyons carved through harder strata, but fall away by a series of terraces, slopes and ledges, sometimes with outstanding pinnacles and masses carved into irregular and fantastic forms. There are numerous short but deep side canyons and ravines, which in many places afford the only avenues of descent into the main canyon.

Near the summit of the canyon walls there is a stratum of soft but comparatively durable limestone several feet in thickness, locally known as the "upper cap-rock." Above it there is sometimes a slope of gravel or calcareous sand a few feet in thickness; below there is another slope of only partially consolidated calcareous material, sometimes as much as fifty feet in thickness, resting upon a thick bed of sandstone of Triassic age. This latter formation, called the "lower cap-rock," varies greatly in character. In places it is from 50 to 120 feet in thickness and ranges from a sandy shale to a coarse grained sandstone or conglomerate. Below it are the "red beds" of the Permian, consisting of soft, friable sandstones, clay and gypsum. The brick-red color of these deposits, due to the iron oxide which they contain, is imparted to the waters of the stream and gives name and character to the Red River. These soft Permian strata yield readily to erosion and every rain carries away great quantities of material broken down by each rill and temporary torrent. Sections of the cap-rock are constantly being undermined through removal of the softer underlying deposits and huge masses of it frequently piled up at the base of the cliff or in the narrow side canyons. Balancing and "toadstool" rocks are frequent where detached masses of the sandstone surmount columns of the softer material. In such places the scenery of the canyon has quite the aspect of the "bad lands" of the Northwest, and amongst the innumerable hillocks and defiles of the more rugged parts it is hard to realize that one is in the midst of the plains and not in a mountainous country.

Below the level of the plains four principal zones of plant life may be recognized in the canyon. These are the calcareous beds above and below the upper cap-rock, including that stratum, the sandstone section of the lower cap-rock and the broken belt of the Permian deposits below it, the open, comparatively level floor of the main canyon, and the immediate borders of the river and perennial, spring-fed streams. For convenience these may be designated the Upper Cap-rock, Lower Cap-rock and Talus, Canyon-floor and River-bank zones.

The following woody plants were collected in Paloduro Canyon at several points in Randall and Armstrong Counties, Texas, but principally at the J. B. Gamble ranch south of Claude in the latter County, and the brief notes are based on observations made during a rather hasty visit:

Juniperus monosperma (Engelm.) Sarg.

This species, locally called White Cedar, is one of the most conspicuous if not the most abundant of the woody plants. It occurs from the Upper Cap-rock zone, where it is usually low and shrubby, through the Lower Cap-rock-talus zone into the deep protected side canyons. In the last named situations and below high protecting bluffs it sometimes becomes a tree 20 metres or more high and with a trunk diameter of 5 or 6 decimetres.

Juniperus Pinchotii Sudw.

The species was originally described from this locality and I am applying the name to the tree or shrub called Red Cedar in the canyons, with erect rigid branches and large copper-colored fruit. It is commonly not more

than a tall shrub, often sending up a number of stems from burned-off stumps. In more protected situations it becomes arborescent, the largest specimens observed being about 12 or 15 metres in height and 4 or 5 decimetres in trunk diameter. It is rather abundant in the same zones as the last species.

Ephedra Torreyana Wats.

This interesting shrub is usually found near the summit of the canyon walls in the Upper Cap-rock zone. Its naked, Equisetum-like stems are much branched and present a very curious appearance. It was also found near Channing, in Hartley County.

Populus texana Sarg.

One of the commonest and largest tree along the margins of the river, in the deep side canyons and under the protection of cliffs is the Cottonwood, which has recently been described by Professor Sargent under this name. While not attaining the large size of some of the other Cottonwoods, specimens 20 metres high and 75 or 80 centimetres in trunk diameter are frequent. The trunks are often bent and branched from near the ground. This species was observed in Nolan, Garza, Randall, Armstrong and Hemp-hill Counties, and doubtless occurs elsewhere in canyons of the Staked Plains and along the northern border of the Edwards Plateau and probably extends into southwestern Oklahoma.

Salix amygdaloides Anders.

A common Willow in the River-bank zone, both in the canyons and in more open situations wherever there are running streams or pools. A tree sometimes 10 or 12 metres high.

Salix exigua var. *stenophylla* (Rydb.) Schneid.

A shrub or slender tree found rarely in the River-bank zone and watered side canyons. Much more abundant along pool and stream margins in more open situations on the plains.

Quercus Mohriana Rydb.

Very abundant along the Upper and Lower Cap-rock-talus zones. Usually a shrub from one to three metres high, but in the protection of cliffs and in deep side canyons sometimes becomes a tree seven or eight metres high, with thick, rough, pale bark and a low conical crown. The leaves are quite variable in size and shape.

Celtis laevigata var. *texana* Sarg.

A small tree common in the Canyon-floor and River-bank zones, and less abundant in the higher zones of the canyon walls.

Mahonia trifoliata Moric.

This curious and rather pretty shrub of the arid Southwest, called Argireta by the Mexicans, is occasionally found in the Lower Cap-rock-talus zone.

Morus microphylla Buckl.

The Mexican Mulberry, a typical tree of the Edwards Plateau, appears to be rather rare except along the southern border in the Staked Plains. In the canyon a few specimens were seen in the Lower Cap-rock-talus zone.

Prunus angustifolia Marsh.

Found occasionally in small thickets in the Canyon-floor and River-bank zones.

Prunus virginiana var. *demissa* (Nutt.) Torr.

Growing in deep watered side canyons and under the protection of bluffs near water.

Cercocarpus argenteus Rydl.

A common and typical shrub of the Upper Cap-rock zone. Seldom more than two or three metres high.

Prosopis glandulosa Torr.

The Mesquite is one of the commonest ligneous plants in the canyon. It is most abundant in the Canyon-floor zone, where it becomes a tree, sometimes ten metres or more in height, but it is also found along the margins of the river and along the sides of the canyon to the upper plains. In the last-named situation it is struggling to maintain and extend a precarious foothold on the open, wind-swept surface, but it seldom becomes more than a shrub two or three metres in height.

Mimosa borealis Gray.

The low, thorny Cat's Claw grows in similar situations to the Mesquite but is perhaps commonest in the broken, rocky ground below the lower cap-rock.

Dalea formosa Gray.

This diminutive shrub is rather common in rocky ground of the Lower Cap-rock zone and is less frequent in the zones above and below.

Gleditsia triacanthos L.

There is a small grove of Honey Locust trees in the Club House grounds near Canyon City and it is said to occur sparingly elsewhere in the upper part of the canyon. The trees seen are of small size for the species, averaging, perhaps, eight or ten metres in height. It appears to be absent lower down in the canyon.

Amorpha fruticosa L.

Rather frequent in the River-bank zone and in low places of the Canyon-floor zone.

Amorpha canescens Pursh.

Collected along the banks of a small ravine above the upper cap-rock. Apparently not common.

Glossopetalon spinescens Gray.

This is one of the most interesting shrubs found in the canyon from the standpoint of plant distribution. On the Edwards Plateau I observed it only along the western and southern borders in Uvalde County and in the Devils River region, where it seems to have come in from the Trans-Pecos country. In the Paloduro Canyon it grows on calcareous banks of the Upper Cap-rock zone. It was seen near Canyon City, in Randall County, and south of Claude, in Armstrong County.

Ribes aureum Pursh.

In deep canyons and along protecting cliffs in the Upper and Lower Cap-

rock-talus zones. Found in Noran, Irion, Garza, Randall, Potter and Armstrong Counties, also in Woodward County, Oklahoma.

Ptelea trifoliata var. *mollis* Torr. & Gray.

Not uncommon on dry rocky banks and in open situations throughout the canyon.

Rhus trilobata Nutt.

Abundant on rocky banks in the Lower Cap-rock-talus zone and less frequent in the zones above and below it.

Rhus microphylla Engelm.

A common shrub in the open Canyon-floor zone and not uncommon in the Lower Cap-rock zone.

Rhus Toxicodendron L.

Grows as a low shrub, usually less than a metre high, in the protection of bluffs. Most abundant in the Upper Cap-rock zone. The scandent form was not observed anywhere in the Staked Plains.

Opuntia leptocaulis DC.

Common in the Canyon-floor zone and extending into the zone above.

Atriplex canescens (Pursh) James.

A common shrub in the Canyon floor and Lower Cap-rock zones.

Zizyphus obtusifolius Gray.

One of the commonest shrubs in the Canyon-floor zone and extending into the zone above.

Sapindus Drummondii Hook. & Arn.

The Soapberry, usually called Wild China or Wild Chinaberry in Texas, is a common tree in the canyon, generally growing in the open ground of the Canyon-floor zone or on the river banks. It sometimes extends to the foot of the lower cap-rock.

Forestiera neo-mexicana Gray.

A common shrub on rocky banks from the Lower Cap-rock to the River-bank zone.

Forestiera pubescens Nutt.

In similar situations to the last but less common.

Lycium Berlandieri Dunal.

In the open ground of the Canyon-floor zone and extending into the zone above.

Lonicera albiflora Torr. & Gray.

Not very common on steep banks of side canyons and along the upper cap-rock.

Cephalanthus occidentalis L.

Frequent along river banks and in depressions of Canyon-floor zone.

Baccharis halimifolia L.

Not very common in the River-bank zone and along margins of spring branches in side canyons.

Baccharis salicina Torr. & Gray.

Occasional on gypseous banks below the lower cap-rock.

Baccharis Wrightii Gray.

A low shrub in open situations in the canyon and on the upper plains.

Bigelovia pulchella Gray.

On rocky banks of Upper and Lower Cap-rock zones.

Bigelovia graveolens (Nutt.) Gray.

A diffuse shrub, one to one and a half metres high, with densely canescent foliage and stems. Grows on calcareous or gypseous banks of Upper and Lower Cap-rock zones.

Brickellia Wrightii Gray.

On dry banks in Upper and Lower Cap-rock zones.

Artemisia filifolia Torr.

Often common in sandy open situations on the upper plains, and sometimes found in the canyon from the Upper Cap-rock zone to the canyon floor.

Clematis Simsii Sweet.

Found in deep-watered side canyons. Not common.

Celastrus scandens L.

The Bittersweet vine was noted in only one locality, in a protected situation at the head of a deep side canyon.

Vitis Longii Prince.

Commonly grows as a low shrub a metre or so high in the protection of low bluffs in the Upper Cap-rock zone. In the deeper side canyons and along bluffs of the Lower Cap-rock talus zone it sometimes becomes a vine several metres high. This species is also very abundant, in the shrubby form, in the deep sands bordering the Canadian River, farther north.

Vitis rupestris Scheele.

Low bushy plants, which from the leaf form appeared to belong to this species, were found at one point in the talus below the lower cap-rock. As there was no fruit it may possibly be only a form of the last-named species.

From the foregoing list it will be seen that the assemblage of woody plants in the canyons is a rather heterogeneous and remarkable one. It must be remembered, too, that even here the trees and shrubs constitute only a small proportion of the entire flora. While it is not within the province of this article to enter into a detailed description of the non-ligneous plants it may be noted that they appear to have been drawn from no less varied sources and an investigation of them may contribute largely to an understanding of the origin of the trees and shrubs with which they are associated. In the protection of high bluffs and at the heads of deep canyon branches, where perennial springs afford a considerable supply of water, the herbaceous growth becomes in places quite luxuriant. Dripping banks are clothed with the Venus' Hair fern (*Adiantum Capillus-Veneris*); there are mossy ledges and boggy beds of Equisetums, rushes and the tall plummy grass, *Phragmites communis*, and many other surprises in moisture-loving plants are encountered. Their presence in these canyons in the midst of the grassy plains, associated with a comparatively rich ligneous flora, and so far removed in many cases from the main body of their kind and kindred,

suggests many interesting questions. In seeking the answers the origin of the plains topography and especially that of the canyons must be taken into account no less than the present ecological conditions and the possible agencies of transportation that have coöperated in developing the flora and giving it its present composition.

All of the phenomena observable in the canyons serve to impress the observer with a realization of how rapidly the work of excavation is going on and how comparatively modern their entire history may be. The remarkable facility with which some of the small streams have been able to cut deeply for many miles back into the plains plateau is attributable not only to the generally soft character of the deposits encountered but also probably to a recent uplift of the region, after the streams had defined their present courses, thus increasing the gradient and augmenting their erosive activities as they approached the escarpment.

It was the writer's good fortune in one respect, although not conducive to comfort or successful plant collecting at the time, to be in the Paloduro Canyon during a very heavy rainfall. Through the greater part of a day and night the rain came down in torrents, and when it slackened on the following morning the little stream across which I had waded several times on stepping-stones, scarcely wetting my boots, had become a roaring torrent more than a hundred yards across in places; fences and water-gates had been carried away and many of the Cottonwood, Mesquite and other trees along the river margins had been uprooted and borne down stream through the undermining of the banks, which were still crumbling at a rapid rate. On every hand could be heard the crashing and booming of falling earth and rock. When it became possible to approach the walls of the canyon and enter the deep side galleries the destructive effects of the elemental warfare were everywhere apparent. Great sections of the cap-rock ledges had been undermined and had tumbled down into the stream or were piled up at the base of the cliffs and slides of rock and earth on a large scale were going on in the saturated and fragile beds for some time after the storm.

The new sections of unoccupied land thus constantly being exposed invite the settlement of such plant pioneers as can gain a foothold. The competition between these first settlers is usually very slight but not all of them that have the hardihood to attempt colonization on these often dry and sterile lands succeed or prosper. Many tragedies ensue, too, from the unstable nature of the rapidly changing surface; but gradually those species, amongst the plants available or such as fortuitously enter the area, which are best adapted to all of the conditions encountered establish themselves and become dominant.

In general the protection afforded in the canyons from the almost constant force of the dry winds of summer and the cold blasts of winter that prevail upon the open plains, together with the more abundant water supply and the diversity of surface and soil are favorable to the development of a rich and varied flora and make possible there the growth of many plants that cannot survive beyond their limits in the Staked Plains region. There

are no permanent human settlements in the Paloduro Canyon and probably no consecutive weather records have been kept, but I was assured that the average winter temperature is several degrees warmer than that of the open plains. Cattle are wintered in the canyons without feeding or artificial shelter and without losses such as occur in the open country above. Based upon a study of the wild life, principally the fauna, the United States Biological Survey has designated the canyons as extensions of the Lower Austral, while the surrounding plains area belongs to the Upper Austral zone.

The plants peculiar to the canyons appear to be emigrants from various sources. Most of them have doubtless advanced gradually or been transported directly over wide intervening distances by various agencies from the Edwards Plateau region to the south; some appear to have come in by way of the upper Pecos valley from extreme southwestern Texas, amongst them such woody forms as *Glossopetalon*, *Ephedra*, *Lycium* and various Composites; others have evidently worked their way along the margin of the plateau and thence up the canyons as they have excavated their way back into the interior; of this class probably are the Junipers, Hackberry, Shin Oak and Soapberry or Wild China; still others, like the Willows and Cottonwoods, may have been introduced from the northwest through the Canadian River valley. The Honey Locust, Bittersweet vine and some of the herbaceous species present special problems of peculiar interest as to their origin and method of introduction. In the case of *Gleditsia triacanthos* the rather heavy seeds must have been transported from sections far to the east or southeast, the lower Brazos valley or the valley of Red River in eastern Texas and Oklahoma being the nearest sections where it occurs, so far as I am aware.

One of the best internal evidences of a newly established or changing flora is the lack of completeness and general balance in its composition and organization as compared with that of the zone it occupies and similar adjacent regions from which its plant population must have been drawn. In a plant society long established this adjustment has been brought about by ages of keen competition and elimination, compelling each surviving member to make the most of every opening and every available space; while in a newly invaded region not only is there evidence of the somewhat confused mingling of the old and new elements but the recent emigrants are arranged in a more or less haphazard way and are apparently seeking their true position or experimenting on the possibility of finding a permanent place in the flora. This partial lack of symmetry and order in the plant society may, if the geological history and physiographic development of the region as well as of the ever changing boundaries of the flora are not kept clearly in mind, be as little explicable under the modern theory of plant succession as under the old discarded idea of special creation, by which each species was supposed to have been placed for definite useful purposes in the particular environment for which it was best fitted: for plants perfectly adapted to a region that has undergone profound climatic or physiographic changes do

not spring up spontaneously; they must find means and await opportunities for entering the new territory, and these may be long delayed, thus allowing less suitable species to occupy it temporarily in the absence of competition.

Considering the geographical position and ecological conditions of the canyons certain woody plants are as conspicuous for their absence as others are surprising by their presence. Possibly a more extensive and thorough exploration than I was able to make might discover some of the plants mentioned below, but in a careful though brief examination of some of the most typical and heavily wooded portions of the Paloduro Canyon I found no trace of them. Conditions in the River-bank zone of the canyon appear to be ideal for the growth of the Mexican or Riverside Walnut (*Juglans rupestris*), which is such a common and characteristic tree along all the streams of the Edwards Plateau, and which approaches the Staked Plains at least as near as Sweetwater, Texas, and extends northward into the Wichita Mountains of Oklahoma; but it does not appear to have as yet found means of entering the canyon. The Pecan, too, should thrive and easily maintain itself along the river banks were it once introduced, and it would have no very wide distance to bridge from the upper Pease River, in Hardiman County, Texas, where it was observed growing spontaneously. It is also surprising that only one species of Oak has found its way into the canyons, since several shrubby and arborescent forms occur not far to the south and east. The American Elm and Red Mulberry might both be expected in the River-bank zone, but neither of them were seen, although the former at least is growing in the valley of the Canadian River on the northern border and along the upper Colorado not far to the southeast. No species of Red Haws, Roses, Blackberries, Viburnums, Dogwood, Ash nor many other plants that might naturally be expected were seen.

The entire absence of many plant families and the poor representation of others which are largely developed in the surrounding country and some of which seem well adapted to conditions here, together with the miscellaneous character of the plants that have become established are all strongly suggestive of the extremely new and incomplete status of the flora. There are, too, so far as known, no endemic species and a general absence of well-marked varieties such as would naturally have been developed had many of the species been long isolated under the peculiar conditions obtaining in the canyons from the parent stock and normal habitat.

All this is in striking contrast to the peculiar canyon flora of the Edwards Plateau, where more or less modified representatives of a typical eastern flora occupy certain restricted areas. If the former may be compared to remnants of aboriginal tribes surviving in isolated fastnesses amidst an alien and conquering race, the assemblage of plants in the Paloduro and other canyons of the Staked Plains may better be likened to the heterogeneous society in process of formation and adjustment drawn from many sources to a newly opened land. Here, in fact, are found many of the phenomena of a flora in the making, and one that has not yet reached a state of even approximate equilibrium or attained a well-balanced and permanent form.

In speaking of the very recent history and development of these canyons and their flora it is not, of course, intended to imply that they are to be considered in terms of a few years or even centuries. Some of the Juniper trees in the Paloduro Canyon are probably not less than one to two hundred years old, and we have no reason to assume that in them we are looking upon the original patriarchs of their race; but in comparison with some of the adjacent physiographic regions and as measured by the standards of geologic time and biologic evolution both appear extremely modern. Some of the plants, on the other hand, may have appeared only in the last few years and other emigrants may be expected from time to time, some of which will be only transient while others will establish themselves and become in time conspicuous and important additions to the flora.

Probably the two principal agents in introducing new plants into the canyons are at present, as they have been in the past, wind and migratory birds. The large proportion of southwestern species and the absence or comparative paucity of those from the contiguous regions to the east and northeast is doubtless due to the circumstance that during the season when seeds of most plants ripen and can be transported and successfully sown the direction of both of these agencies is from the south or southwest northward. Some of the lighter seeds, with special provisions for transportation through the air, may be carried almost incredible distances by such strong and persistent winds as prevail upon the plains. As there are few inequalities on the surface to arrest their progress, they would in many cases find lodgment only, at least in situations where there would be any chance for them to germinate and survive, when swept into the canyons that lie across their northward course.

Many birds breed in the canyons and others in their passage northward, doubtless, stop for a time in its protection. It is to be regretted that no definite data can be given either as to the meteorology or ornithology of the canyons to determine their relative and absolute importance as agencies in plant introduction. Their investigation, however, would prove a most interesting and fruitful field for a local observer with the taste and opportunity for pursuing it. Amongst the birds noted in the Paloduro Canyon, which are persistent seed eaters and probable agents in plant introduction are the Western Mockingbird, Texas Quail, Texas Jay and species of Woodpecker, Vireo and Oreole. Other birds seen were the Canyon Wren, Horned Lark, Poor Will, Cliff Swallow and Western Chipping Sparrow, and I was reliably informed that both the Mexican and Bald Eagle are found.

An analysis of the list of forty-five woody species given for the Paloduro Canyon reveals the fact that no less than twenty-three, or more than half, produce fruit attractive to ordinary seed-eating birds; while the seeds of the Shin Oak and most of the Legumes might have been transported by larger birds or mammals. Fifteen, including the Willows, Cottonwood, Wafer Ash, Button Bush, Virgin's Bower and the Composites are more or less perfectly adapted to wind transportation. In view of the inference that birds have probably been one of the chief agencies in bringing new plants

into the canyons it may at first seem the more surprising that no representatives of the large Red Haw group and some of the other *Rosaceae*, whose fruit is so attractive and which are commonly transported through their migrations over wide areas, should have found their way here. The explanation is no doubt found in the fact that species of these groups are rare or absent from most of the Edwards Plateau region and from that to the southwest.

WEBB CITY, MISSOURI, April, 1920

A NEW SPECIES OF PISTACIA NATIVE TO SOUTHWESTERN TEXAS, *P. TEXANA*

WALTER T. SWINGLE

IN 1859 John Torrey¹ reported *Pistacia mexicana* HBK. as occurring in Texas in "Rocky ravines near the mouth of the Pecos, western Texas, October (fruit); Bigelow. A small tree."

In 1891 John Coulter² included the species *Pistacia mexicana* HBK. in his Botany of Western Texas, with a very brief description, ending with the following statement: "A small Mexican tree, with an edible nut,³ said to occur near the mouth of the Pecos."

In 1897 Asa Gray⁴ described fruiting material in some detail in his Synoptical Flora and, although he had not seen the flowers, transferred the species to the genus *Rhus* as the sole species of a new section, *Pistacioides*. The name *Rhus mexicana* Gray, is cited as having been published "in Patterson, check-list, 1892, 21," but this check-list (Patterson's Numbered Check-list of North American Plants, North of Mexico, p. 21. [Oquakwa, 1892]) gives merely a *nomen nudum*, "RHUS . . . 1690 Mexicana Gray." with no citations of the previously published *Pistacia mexicana* HBK.

In 1905 Vernon Bailey,⁵ in his Biological Survey of Texas, assigns the plant to *Schmaltzia* (a segregate of *Rhus*, based on *Rhus aromatica*, Ait.) as *Schmaltzia mexicana*, citing *Rhus mexicana* and *Pistacia mexicana* as synonyms, and notes its relationship to the *Pistacia vera* from which the pistache nut of commerce is obtained. He goes on to say, "In places in the canyons of the Rio Grande this large shrub grows in profusion, suggesting that the real *pistachio* also might succeed here."

Aside from occasional citations of the scanty information given in these

¹ Torrey, John. Botany of the Boundary, in Emory, William H., Report on the United States and Mexican Boundary Survey (34th Cong. 1st Sess. Senate Ex. Doc. No. 108). II. pt. 1, p. 44 (Washington, 1859).

² Coulter, John M. Botany of Western Texas, in Contributions from the U.S. National Herbarium, Washington, D.C. II. 67 (June 27, 1891).

³ This is an error, as the seeds are too small to be classed as edible.

⁴ Gray, Asa. Synoptical Flora of North America, I. 386, also p. 381 (Part 1, fasc. 2, June 10, 1897).

⁵ Bailey, Vernon. Biological Survey of Texas, in North American Fauna (U.S. Dept. Agriculture). No. 25, p. 30. (Washington, 1905.)